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## ARTICLE VII.

*On the Longitude of Several Places in the United States, as deduced from the Observations of the Solar Eclipse of September 18th, 1838. By E. Otis Kendall, Professor of Mathematics in the Central High School of Philadelphia. Read November 1, 1839.*

This eclipse was observed at the following places:—

	LATITUDE.	LONGITUDE.
		From Greenwich.
		<i>h. m. s.</i>
Hudson Obs'y, Western Reserve College, Ohio, .	+ 41° 14' 37"	— 5 25 47·5
Alexandria, D. C., . . . . .	+ 38 49 0	— 5 8 16·0
Washington, Capitol, . . . . .	+ 38 53 23	— 5 8 6·0
Haverford School, Delaware County, Pa., . . .	+ 40 1 12	— 5 1 15·0
Philadelphia, State House, . . . . .	+ 39 56 58	— 5 0 39·0
Germantown, Pa., C. Wister's private Observatory,	+ 40 1 59	— 5 0 41·9
Burlington, N. J., S. Gummere's School, . . .	+ 40 5 10	— 4 59 30·1
Princeton, N. J., Nassau Hall, . . . . .	+ 40 19 56	— 4 58 38·3
Weasel Mountain, N. J., Station of Coast Survey,	+ 40 52 35	— 4 57 25·7
New Haven, Yale College, . . . . .	+ 41 17 58	— 4 51 47·5
Southwick, Mass., A. Holcomb's private Obs'y, .	+ 42 0 41	— 4 51 16·0
Wesleyan University, Conn., . . . . .	+ 41 33 8	— 4 50 2·0
Williamstown College, Mass. . . . .	+ 42 42 44	— 4 52 52·0
Dorchester Observatory, Mass., . . . . .	+ 42 19 11·5	— 4 44 17·3
Dover, Tuscarora County, Ohio, . . . . .	+ 40 30 52	— 5 25 56·2
Brooklyn, N. Y., E. Blunt's private Obs'y, . . .	+ 40 42 0	— 4 56 0·0

When there were more observers than one at the same place, I have taken the mean of all the observations, giving to each its proper weight. In Philadelphia it was observed by several persons, in different parts of the city. The following table contains a list of the Philadelphia observations, with the differences of latitude and longitude between the places of observation and the State House, which has been already published in the Proceedings of the Society, vol. I. p. 36.

Observer.	Latitude, + North, — South of State House.	Longitude, + East, — West of State House.	Beginning.	Formation of Ring.	Rupture of Ring.	End.
			<i>h. m.</i> 3 13	<i>h. m.</i> 4 31	<i>h. m.</i> 4 35	<i>h. m.</i> 5 45
E. J. Bean	+ 70".0	<i>s.</i> — 1.70			<i>s.</i> 28.4	
Wm. Penn Cresson	+ 1.8	— 5.20			27.8	
Prof. W. R. Johnson	+ 1.8	— 5.20	<i>s.</i> 10.7		23.5	<i>s.</i> 12.2
George M. Justice	+ 10.0	— 2.86	7.4	<i>s.</i> 12.8	27.3	11.3
E. O. Kendall	+ 10.0	— 2.86	8.3	10.9	28.4	12.9
Joseph Knox	+ 21.0	+ 1.39	12.8			
Isaiah Lukens	+ 9.0	— 0.86		21.7		
Thomas M'Euen	— 0.4	— 2.33	3.0	18.1	29.1	13.2
Prof. Roswell Park	+ 6.5	— 1.30		19.1	29.1	
Dr. R. M. Patterson	+ 1.1	— 1.20	7.0	19.1	30.1	16.1
Wm. H. C. Riggs	— 0.4	— 2.33	7.3	16.3	29.4	7.8
Samuel Sellers	+ 7.5	— 0.05	6.0	16.0	31.0	16.0
Tobias Wagner	+ 10.0	— 2.86	6.1			
Sears C. Walker	+ 10.0	— 2.86	5.6	15.6	28.0	13.0
William Young	— 21.0	+ 1.39		12.9		15.0

It was considered most convenient to reduce the above local times to the State House, which has been done by means of the formulæ in the Journal of the Franklin Institute, vol. xx. p. 125, by which I have deduced the following values of the variation of the local time of the several phases for a small difference of terrestrial latitude or longitude.

	Beginning.	Ring.	End.
Variation for + or North 1" of terr. lat. . . .	= — 0.0397	— 0.0382	— 0.0343
" + or East 1s. of terr. lon. in time . . .	= + 1.2600	+ 1.1400	+ 0.9925

Applying these values, and taking means after giving due weight to each observation, the results for the State House are obtained as stated below.

The method used in making these reductions is that of Bessel. Astr. Nach. No. 321. The sun's semi-diameter there given has been employed; the other elements have been taken from the Nautical Almanac. Bessel's semi-diameter of the sun is less than that of the Nautical Almanac by 1".112. I have computed the following co-ordinates for this eclipse, and would remark that the

reduction of future observations of solar eclipses will be much facilitated by the publication of these co-ordinates in the Berliner Jahrbuch since 1839.

Mean Time. Greenwich.	$\alpha$	$\delta$	$\pi$	$\alpha'$	$\delta'$	$\log r$
<i>h.</i>	<i>h. m. s.</i>			<i>h. m. s.</i>		
7	11 41 33.74	+ 2° 57' 14".9	53' 53".78	11 43 3.48	+ 1° 50' 10".5	0.0017425
8	43 17.49	2 43 4.6	.67	12.46	49 12.3	375
9	45 1.79	2 28 53.9	.56	21.44	48 14.0	325
10	46 45.75	2 14 42.6	.47	30.42	47 15.7	275
11	48 29.67	2 0 31.0	.38	39.40	46 17.4	224
12	50 13.55	1 46 19.0	.30	48.38	45 19.2	174

Mean Time. Greenwich.	$\alpha$	$d$	$\log g$	$x$	$y$	$\log z$
<i>h.</i>	<i>h. m. s.</i>					
7	11 43 3.72	+ 1° 49' 59".8	9.9988515	— 0.4168225	+ 1.2478116	1.8046400
8	12.45	49 3.7	512	+ 0.0247623	+ 1.0022355	6936
9	21.17	48 7.5	510	+ 0.4663195	+ 0.7566013	7198
10	29.90	47 11.3	511	+ 0.9078406	+ 0.5109066	7162
11	38.63	46 15.1	511	+ 1.3492845	+ 0.2651588	6852
12	47.36	45 19.0	513	+ 1.7906058	+ 0.0193279	6258

Mean Time. Greenwich.	$l$	$\log i$	$l'$	$\log i'$
<i>h.</i>				
7	0.5695708	7.6682157	0.0231215	7.6661003
8	6110	2210	1615	1056
9	6326	2262	1831	1108
10	6334	2311	1839	1157
11	6150	2362	1662	1208
12	5782	2410	1291	1256

$T = 9^h$			$T = 10^h$		
$p = + 0.4663195 \quad q = + 0.7566013$			$p = + 0.9078406 \quad q = + 0.5109066$		
$T'$	$N$	$\log \frac{S}{n}$	$T'$	$N$	$\log \frac{S}{n}$
— 2 <sup>h</sup>	119° 4' 59".4	3.8527713	— 2 <sup>h</sup>	119° 5' 26".7	3.8527704
— 1	5 12.4	7696	— 1	5 41.1	7713
0	5 26.1	7672	0	5 56.2	7846
+ 1	5 41.1	7713	+ 1	6 15.4	8071
+ 2	5 58.3	7893	+ 2	6 42.3	8358

Then, according to Bessel, calling  $d$  the longitude + East, — West of Greenwich, we have

$$d = d' + a\varepsilon + b\xi + c\eta$$

Where

$d'$  = the resulting longitude, uncorrected for the errors of the tables

$\varepsilon$  = the correction of the tabular place of the moon on its orbit

$\xi$  = “ “ “ on a perpendicular to its orbit

$\eta$  = “ “ “ sum of the semi-diameters of the sun and moon

$\eta'$  = “ “ “ difference “ “

With these elements and co-ordinates I have computed the following values of  $d'$  and the co-efficients  $a$ ,  $b$ ,  $c$ , assuming the ellipticity of the earth to be 0.00324.

Place of Observation and Observer.	Mean Time of Observation.	$d'$	$a$	$b$	$c$	$d$
	<i>h. m. s.</i>	<i>h. m. s.</i>				<i>h. m. s.</i>
Western Reserve Coll. <i>Prof. Loomis.</i>	B. 2 38 17.02	— 5 25 3.59	+ 2.203	— 0.355	+ 2.232	— 5 25 40.70
	E. not observed					
Dover, Ohio, <i>J. Blickensderfer.</i>	B. 2 39 38.82	— 5 25 15.71	+ 2.203	— 0.372	+ 2.235	— 5 25 52.71
	F. R. 4 0 25.71	20.28	+ 2.204	— 0.848	+ 2.361	45.44
	R. R. 4 6 9.63	23.67	+ 2.204	+ 0.302	— 2.224	59.60
	E. 5 18 3.64	35.04	+ 2.204	— 0.151	— 2.209	59.45
Alexandria, D. C., <i>B. Hallowell.</i>	B. 3 5 52.00	— 5 7 46.94	+ 2.203	— 0.298	+ 2.223	— 5 8 24.44
	F. R. 4 24 6.0	7 58.40	+ 2.204	— 0.093	+ 2.205	29.16
	R. R. 4 30 13.0	7 45.26	+ 2.204	— 0.345	— 2.229	16.46
	E. 5 39 25.0	8 14.22	+ 2.204	— 0.131	— 2.208	38.79
Washington Capitol, <i>R. T. Paine and Lieut. Gillis, U. S. N.</i>	B. 3 6 9.23	— 5 7 25.73	+ 2.203	— 0.294	+ 2.223	— 5 8 3.25
	F. R. 4 24 27.61	31.39	+ 2.204	— 0.014	+ 2.204	2.72
	R. R. 4 30 18.05	31.96	+ 2.204	— 0.405	— 2.240	2.73
	E. 5 39 54.76	37.42	+ 2.204	— 0.134	— 2.208	1.96
Haverford School, Pa., <i>J. Gummere &amp; S. J. Gummere.</i>	B. 3 12 17.59	— 5 0 34.07	+ 2.203	— 0.231	+ 2.216	— 5 1 12.03
	F. R. 4 30 29.63	32.43	+ 2.204	+ 1.412	+ 2.617	13.98
	R. R. 4 34 44.80	53.95	+ 2.204	— 1.961	— 2.949	13.71
	E. 5 44 28.24	53.43	+ 2.204	— 0.165	— 2.210	17.73
Philadelphia, State House, <i>Several Observers.</i>	B. 3 13 10.06	— 4 59 59.81	+ 2.203	— 0.229	+ 2.215	— 5 0 37.79
	F. R. 4 31 18.76	— 4 59 57.12	+ 2.204	+ 1.420	+ 2.621	38.72
	R. R. 4 35 31.35	— 5 0 20.44	+ 2.204	— 1.965	— 2.952	40.16
	E. 5 45 15.46	— 5 0 15.01	+ 2.204	— 0.164	— 2.210	39.32
Germantown, Pa., <i>Charles Wister &amp; Casper E. Wister.</i>	B. 3 12 54.9	— 5 0 3.00	+ 2.203	— 0.228	+ 2.215	— 5 0 40.99
	F. R. 4 31 8.9	— 4 59 58.59	+ 2.204	+ 1.501	+ 2.665	40.75
	R. R. 4 35 18.4	— 5 0 19.83	+ 2.204	— 2.070	— 3.023	38.83
	E. 5 45 7.9	— 5 0 12.56	+ 2.204	— 0.166	— 2.210	36.06
Burlington, N. J., <i>Prof. Hamilton.</i>	B. 3 14 23.7	— 4 58 46.65	+ 2.203	— 0.220	+ 2.214	— 4 59 24.69
	F. R. 4 32 32.6	58 45.13	+ 2.204	+ 1.743	+ 2.810	28.99
	R. R. 4 36 19.6	59 12.50	+ 2.204	— 2.350	— 3.222	29.55
	E. 5 46 8.5	59 6.07	+ 2.204	— 0.168	— 2.210	30.35

Place of Observation and Observer.	Mean Time of Observation.	$d'$	$a$	$b$	$c$	$d$
	<i>h. m. s.</i>	<i>h. m. s.</i>				<i>h. m. s.</i>
Princeton, N. J., <i>Profs. Henry &amp; Alexander.</i>	B. 3 14 43·01	— 4 58 5·27	+ 2·203	— 0·167	+ 2·213	— 4 58 43·69
	F. R. 4 33 11·27	57 56·31	+ 2·204	+ 2·245	+ 3·146	43·68
	R. R. not observed					
Weasel Mountain, N. J. <i>F. R. Hassler.</i>	E. 5 46 38·89	58 6·47	+ 2·204	— 0·174	— 2·210	30·70
	B. 3 15 56·98	— 4 56 8·50	+ 2·203	— 0·189	+ 2·211	— 4 56 46·75
	F. R. 4 35 57·09	55 29·15	+ 2·204	+ 6·875	+ 7·220	48·26
	R. R. 4 35 58·09	57 3·33	+ 2·204	— 6·912	— 7·255	49·10
Brooklyn Obs'y, N. Y., <i>E. Blunt.</i>	E. 5 47 13·10	56 27·21	+ 2·204	— 0·187	— 2·213	51·34
	B. 3 17 18·80	— 4 55 21·76	+ 2·203	— 0·189	+ 2·211	— 4 56 0·02
	F. R. 4 36 47·30	54 52·24	+ 2·204	+ 5·329	+ 5·766	0·80
	R. R. not observed					
New Haven, <i>Prof. Olmsted, E. P. Mason, &amp; H. L. Smith.</i>	E. 5 48 23·63	55 38·15	+ 2·204	— 0·184	— 2·211	2·31
Southwick, Mass., <i>A. Holcomb.</i>	B. 3 21 14·47	— 4 51 9·15	+ 2·203	— 0·155	+ 2·209	— 4 51 47·65
	E.* 5 51 17·00	32·78	+ 2·204	— 0·199	— 2·213	56·82
Wesleyan Univ., Conn., <i>Prof. A. A. Smith.</i>	B. 3 20 19·0	— 4 50 38·31	+ 2·203	— 0·139	+ 2·208	— 4 51 16·92
	E. 5 50 27·0	56·24	+ 2·204	— 0·215	— 2·214	20·16
Williamstown Coll., <i>Prof. Hopkins.</i>	B. 3 22 0·81	— 4 50 5·04	+ 2·203	— 0·145	+ 2·208	— 4 50 43·62
	E. 5 52 1·46	17·74	+ 2·204	— 0·205	— 2·213	41·73
Dorchester, Mass., <i>W. C. Bond.</i>	B. 3 17 19·9	— 4 51 48·27	+ 2·203	— 0·132	+ 2·206	— 4 52 26·93
	E. not observed					
	B. 3 28 10·9	— 4 43 44·01	+ 2·203	— 0·099	+ 2·206	— 4 44 22·76
	E. not observed					

From the duration of the ring the following values of  $\zeta$  were obtained:

At Dover, . . . . .	$\zeta^{(i)}$	= + 2·948 + 3·987 $\times \eta'$
Alexandria, . . . . .	$\zeta^{(ii)}$	= + 52·140 — 17·600 $\times \eta'$
Washington, . . . . .	$\zeta^{(iii)}$	= — 1·457 — 11·370 $\times \eta'$
Haverford, . . . . .	$\zeta^{(iv)}$	= — 6·380 — 1·650 $\times \eta'$
Philadelphia, . . . . .	$\zeta^{(v)}$	= — 6·893 — 1·646 $\times \eta'$
Germantown, . . . . .	$\zeta^{(vi)}$	= — 5·944 — 1·592 $\times \eta'$
Burlington, . . . . .	$\zeta^{(vii)}$	= — 6·688 — 1·473 $\times \eta'$
Weasel Mountain, . . . . .	$\zeta^{(viii)}$	= — 6·831 — 1·050 $\times \eta'$

The mean of the five last equations gives,

$$\zeta = - 6·547 - 1·482 \times \eta'$$

And from the equation for Washington,

$$\eta' = + 0·515$$

$$\text{Whence } \zeta = - 7·310$$

\* It was found necessary to subtract one minute from the time of end as given by Messrs. Olmsted, Mason and Smith.

With the above value of  $\zeta$ , the duration of the eclipse furnished for the value of  $\eta$ ,

At Princeton, . . . .	$\eta^{(i)}$	$= - 0.261 - 0.056 \times \eta'$
Germantown, . . . .	$\eta^{(ii)}$	$= - 2.255 - 0.053 \times \eta'$
Williamstown, . . . .	$\eta^{(iii)}$	$= - 2.875 - 0.022 \times \eta'$
Washington, . . . .	$\eta^{(iv)}$	$= - 2.798 - 0.022 \times \eta'$
Philadelphia, . . . .	$\eta^{(v)}$	$= - 3.534 - 0.022 \times \eta'$
Southwick, . . . .	$\eta^{(vi)}$	$= - 3.941 - 0.017 \times \eta'$
Weasel Mountain, . . . .	$\eta^{(vii)}$	$= - 4.232 + 0.002 \times \eta'$
Burlington, . . . .	$\eta^{(viii)}$	$= - 4.468 - 0.001 \times \eta'$
Haverford, . . . .	$\eta^{(ix)}$	$= - 4.472 + 0.015 \times \eta'$
Dover, . . . .	$\eta^{(x)}$	$= - 4.675 - 0.074 \times \eta'$
New Haven, . . . .	$\eta^{(xi)}$	$= - 5.409 + 0.021 \times \eta'$
Alexandria, . . . .	$\eta^{(xii)}$	$= - 6.403 + 0.025 \times \eta'$
Mean of the twelve equations, . . . .	$\eta$	$= - 3.760 - 0.017 \times \eta'$
Mean of first six, " . . . .	$\eta$	$= - 2.611 - 0.032 \times \eta'$
Mean of two means, . . . .	$\eta$	$= - 3.185 - 0.025 \times \eta'$

$$\text{Whence } \eta = - 3.198$$

Applying these values of  $\zeta$ ,  $\eta$ ,  $\eta'$  to the equations derived from the Philadelphia observations, and assuming  $d$  equal to  $- 5h. 0m. 39.00s.$ , we have

$$\epsilon = \frac{d - d' - b \zeta - c \eta}{a} = - \frac{32.571}{2.2035} = - 14.782$$

And making

$$d = d' - 14.782 \times a - 7.310 \times b + \left\{ \begin{array}{l} - 3.198 \\ + 0.515 \end{array} \right\} \times c$$

we derive the value of  $d$ , or the most probable longitude to be deduced from this eclipse, as given in the table above.